MONTHLY WEATHER REVIEW.

Editor: Prof. Cleveland Abbe. Assistant Editor: Frank Owen Stetson.

Vol. XXXIV. NOVEMBER, 1906. No. 11

The Monthly Weather Review is based on data from about 3500 land stations and many ocean reports from vessels taking the international simultaneous observation at Greenwich noon.

Special acknowledgment is made of the data furnished by the kindness of cooperative observers, and by Prof. R. F. Stupart, Director of the Meteorological Service of the Dominion of Canada; Señor Manuel E. Pastrana, Director of the Central Meteorological and Magnetic Observatory of Mexico; Camilo A. Gonzales, Director-General of Mexican Telegraphs; Capt I. S. Kimball, General Superintendent of the United States Life-Saving Service; Commandant Francisco S. Chaves, Director of the Meteorological Service of the Azores, Ponta Delgada, St. Michaels, Azores; W. N. Shaw, Esq., Secretary, Meteorological Office, London; H. H. Cousins, Chemist, in charge of the Jamaica Weather Office; Señor Anastasio Alfaro, Director of the National Observatory, San José, Costa Rica; Rev. L. Gangoiti, Director of the Meteorological Observatory of Belen College, Havana, Cuba.

As far as practicable the time of the seventy-fifth meridian, which is exactly five hours behind Greenwich time, is used in the text of the Monthly Weather Review.

Barometric pressures, both at land stations and on ocean vessels, whether station pressures or sea-level pressures, are reduced, or assumed to be reduced, to standard gravity, as well as corrected for all instrumental peculiarities, so that they express pressure in the standard international system of measures, namely, by the height of an equivalent column of mercury at 32° Fahrenheit, under the standard force, i. e., apparent gravity at sea level and latitude 45°.

SPECIAL ARTICLES, NOTES, AND EXTRACTS.

RECORDS OF THE DIFFERENCE OF TEMPERATURE BETWEEN MOUNT ROYAL AND McGILL COLLEGE OBSERVATORY, AND A METHOD OF LOCAL TEMPERATURE FORECASTING.

By C. H. McLeod, Superintendent of the Meteorological Observatory, and H. T. Barnes, Associate Professor of Physics, McGill University.
Dated Montreal, Canada, December 5, 1906.

In 1897 the British Association made a grant of £50 toward an investigation of the changes of temperature due to differences in altitude at Montreal. In the early summer of 1899 suitable electric recording instruments were installed in the McGill College Meteorological Observatory, and a wire connection was established between the observatory grounds and a tower, 47 feet high, placed on the summit of Mount Royal. The thermometers were of the ordinary electrical-resistance type, of 10 ohms, composed of coils of .006-inch platinum wire wound on mica frames. The two thermometers constituted a differential pair, and were in consequence carefully adjusted to equality.

The general principle of the Wheatstone's bridge connections for the electrical-resistance thermometer, as designed by Professor Callendar, is already well known. The method of compensation, which consists in placing in the opposite arm of the bridge a loop of wire equal in length and resistance to the thermometer leads and stretching over precisely the same path, renders the records independent of variations of temperature in the connections. These may, therefore, be made of any length desired. Until these records were obtained no test had been made of this compensation system over so great a distance, and it was consequently a matter of some interest to observe how well the method served.

The mountain thermometer is placed near the top of the tower, and is approximately 800 feet above sea level. It is protected by a single screen cage commonly used for protecting observatory thermometers. The cage is hung from the underside of the topmost platform of the tower and is, therefore, protected from the effects of direct radiation. The observatory thermometer is placed four feet above the ground in the cage used for protecting the standard mercury thermometer, and is 187 feet above sea level. The difference in elevation between the two thermometers is therefore 620 feet, and the position of the mountain thermometer is northwest from the observatory. The horizontal distance between the stations is 3300 feet, and the actual length of connecting cable is 4100 feet. The first connection that was made between the mountain top and the observatory was with four ordinary electric light wires of No. 14 gage. These were supported on glass insulators on poles placed at intervals up the side of the mountain. By this means records were obtained of the difference in temperature between the high and low levels during fine and dry weather, but in wet weather the insulation proved so defective as to render successful operation impossible.

It was not until 1903 that a satisfactory cable could be procured and placed in position. A special telephone cable containing eleven paper-covered No. 14 copper wires surrounded by a lead cover was hung from a stout wire supported on the poles. Four of these wires were used for the thermometer circuits, and the remaining wires were used for the anemograph and other instruments required on the tower for the meteorological work. Two of the four wires were used for the thermometer connection proper, and the other two for the compensating loop. Each pair of wires measured 40 ohms resistance.

The readings were commenced under the improved conditions in July of that year, and have extended to the present time, with the exception of two unavoidable delays during the summers of 1904 and of 1905. These were caused by defective repairing of a cut made in the mountain line by some unknown person.

One of the Callendar electric recorders is used to obtain permanent traces of the difference in temperature, and it is arranged to operate on the 100-volt direct-current lighting circuit thru a 16-candle-power lamp.

The pen marking on the record sheet is drawn to one side or the other of the line of equal temperatures, depending on whether the mountain thermometer is warmer or colder than the one at the observatory. A D'Arsonval galvanometer is provided with a light arm about six inches long containing two wires which make metallic contact with two wires on the circumference of a wheel operated by clockwork. Either one or the other wire of the arm touches the corresponding clockwire, depending on the deflection of the galvanometer. When the bridge balance is upset electrical connection is thus made to either of the relays situated to the right and left of a bridge wire 12 inches long. The relays operate clock mechanisms and draw the contact point over the wire to the right or left, depending on the deflection.

The contact point is rigidly attached to the pen recording on paper attached to a drum driven by clockwork. The movement of the contact is in such a direction as to reestablish the balance in the bridge system.

A great deal of attention was directed to the tracing of the base or zero line when all the connections were in the circuit and the thermometers were maintained at equal temperatures. This affords the best check of the efficiency of the compensation system at different seasons of the year. It was seen that the zero line showed small fluctuations on either side, perhaps due to small strains in the wires from wind or other causes, but recently we have very much improved the insulation of the cable, and have to a large measure done away with much of the fluctuation. The deviations were of a magnitude represented by about a degree Fahrenheit on either side of the zero line on the chart, but over the twenty-four hours they averaged out.

When even-ratio coils are attached to the recorder in place of the mountain wires, a perfectly straight line is obtained. The scale is so arranged that a difference of 1° F. between the two thermometers displaces the pen horizontally two small divisions, or two-tenths of an inch. Every large division is one-half an inch and equals 2.5°. The time scale in the direction of revolution of the drum is one-half inch per hour.

It has been arranged that a displacement of the pen to the right indicates warmer on the mountain, while to the left indicates colder conditions. We have arbitrarily called these positive and negative differences, respectively, thus indicating the way the difference has to be applied to the thermograph records of temperature at the observatory to obtain the temperature on top of the mountain.

ANALYSIS OF THE RECORDS.

TABLE 1.—*Average monthly differences in temperature, in degrees F., between summit and base of Mount Royal, Montreal.*

Month.	1903-4.	1904-5.	1905-6.
July	− 5.5	....	....
August	− 4.7	....	....
September	− 5.8	....	....
October	− 7.6	....	....
November	− 4.6	....	....
December	− 8.2	....	− 3.0
January	−11.6	....	− 2.2
February	− 8.1	− 2.7	− 1.6
March	− 5.9	− 2.0	− 2.5
April	− 6.8	− 3.1	− 3.7
May	− 3.7	− 2.6	....
June	....	− 2.2	− 2.5

A study of the various records which we have obtained shows that the temperature at the top of the mountain is normally lower than at the observatory. The accompanying table shows the average monthly differences which so far have been deduced. Each value represents the mean for days of the month and in every case the value is negative. The daily means were obtained from the trace by averaging the values read off at hour intervals. The differences for 1903-4 are conspicuously greater than for the two following years. Whether this fact is in any way connected with the severe weather which was experienced in Montreal during 1903-4 is a matter yet to be settled. It is a striking fact that the average monthly means for the temperature at the observatory from July, 1903, to December, 1905, with only three exceptions, were all below the average for the past thirty years, the departure in two cases amounting to as much as 8° F.

A further significant fact is that smaller differences have preceded or accompanied the mild winter and warm summer of 1906, when the observatory temperature for every month up to date, except two, has been above the average for the past thirty years. January, 1906, was over 8° F. above, while the exceptions, May and July, were less than 3° below the 30-year average.

An interesting feature of our work is the way the trace may be used to predict temperature changes for a short period ahead. It appears that our high-level thermometer is always affected first by any temperature change, and that the time interval may be from five to twenty-four hours in advance of the low-level. Thus a warm or cold wave passes over the mountain first and subsequently comes down to the lower level; the effect is observed on the trace by the traveling of the pen to the right or left and its subsequent return to the normal difference.

In general we find:

(1) Steady normal negative difference (colder on the mountain) indicates continued temperature conditions at the lower station.

(2) Increasing negative difference indicates that the temperature conditions will grow colder at the lower level.

(3) Decreasing negative difference indicates that the temperature will rise at the observatory.

(4) A positive difference indicates a rise of temperature at the observatory.

(5) An increasing or decreasing positive difference indicates changes similarly to a decreasing or increasing negative difference.

The magnitude of the change at the lower station can usually be surmised by observing the magnitude of the change in the differential reading.

A positive wave on the trace has been observed to accompany a heavy fall of snow, as tho rapid crystallization in the upper atmosphere had resulted in a sensible evolution of heat. The direction and velocity of the wind affect the results to a certain extent. Thus the direction frequently determines the approach of colder or warmer weather, and the velocity fixes, to some extent, the time interval between the stations, since a high wind tends to mix the air currents.

The accompanying figures, reproduced from a series of traces, serve to illustrate our meaning. Figs. 1 and 2 are somewhat remarkable from the very large differences indicated. They were obtained on February 1 and 2, 1904, and heralded a considerable temperature depression. The scale is indicated in Fahrenheit degrees, positive above and negative below the zero line. The horizontal scale is for twenty-four hours, beginning with midnight. In fig. 1 the difference increases negatively after 3 a. m., dropping rapidly until 9 a. m., and then remaining fairly constant until 6 p. m., when it drops off more rapidly, until between 11 p. m. and 12 midnight the difference between the summit and the observatory reached as much as 24°. Fig. 2 shows this large difference maintained the next day, with waves of colder air sweeping over the summit at intervals. The character of these records was that of extremely cold weather. Thus, altho fig. 1 indicated a change at 3:30 a. m., showing mountain temperature falling from 22° and reaching 18° at 8:45 a. m., the observatory temperature rose in the same time from 24° to 28°. At this point a sudden change in wind took place, indicated by the small hump at 9 a. m., and the mountain and observatory temperatures fell away together, reaching 0° and 10°, respectively, in about an hour. From 10 a. m. on they remained relatively the same, until at 3 p. m. a great change was indicated. Thus the observatory temperature fell to −10° and the next day reached −20°. On the summit −45° was recorded. Indications of the cold wave extending to the ground in some places were afforded by reports that the mercury had frozen in the thermometers in certain districts. Such a report was received from St. Rose, 20 miles to the north of Montreal. All thru

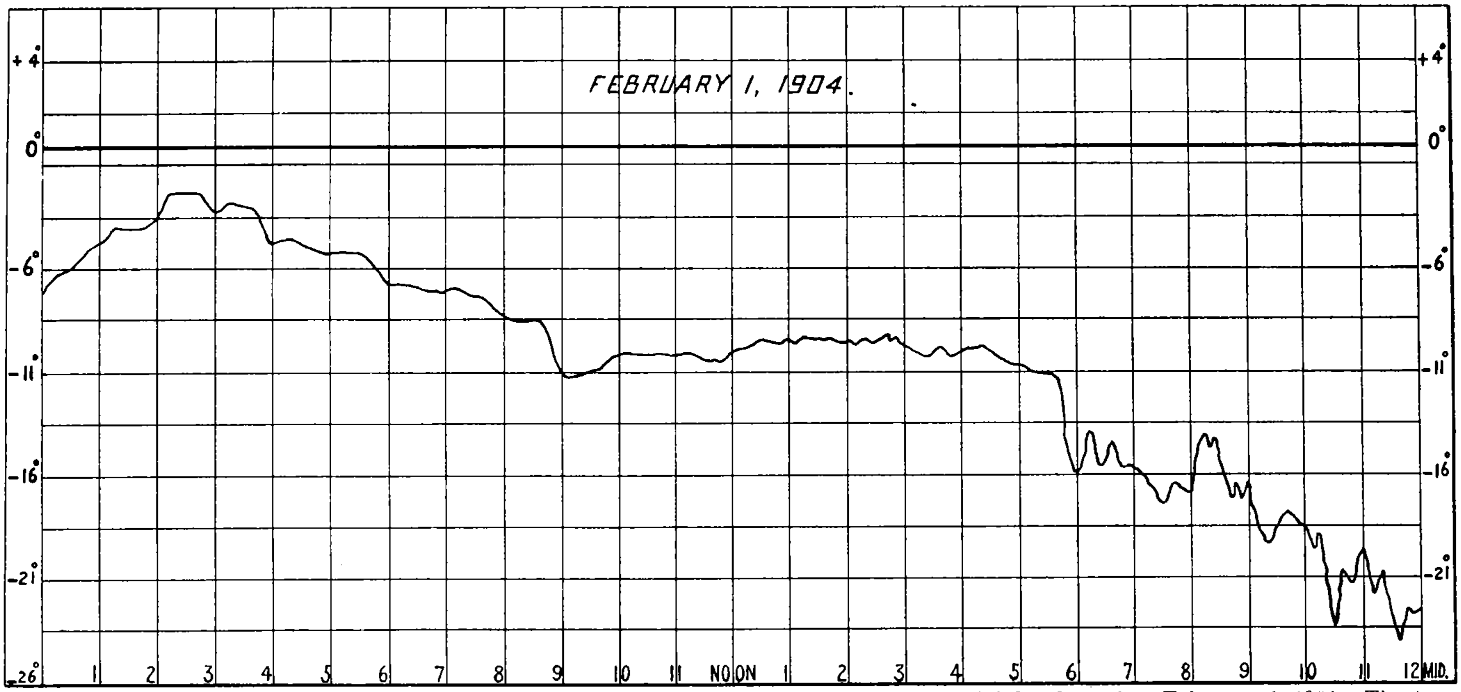

FIG. 1.—Increasing negative temperature difference, showing rapid fall of temperature at high-level station, February 1, 1904. The trace shows the temperature difference in degrees Fahrenheit, the high-level temperature minus the low-level temperature.

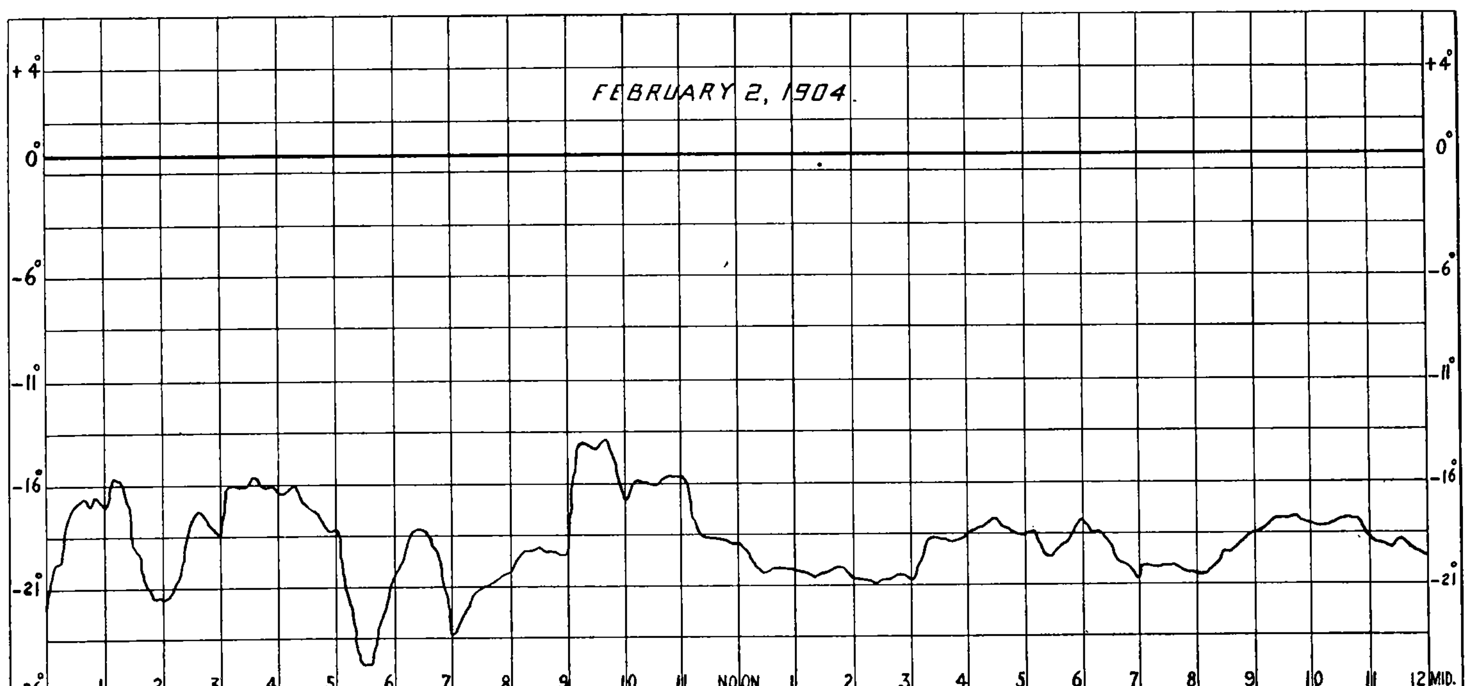

FIG. 2.—Large, steady negative temperature difference, indicating a continuation of low temperatures, February 2, 1904.

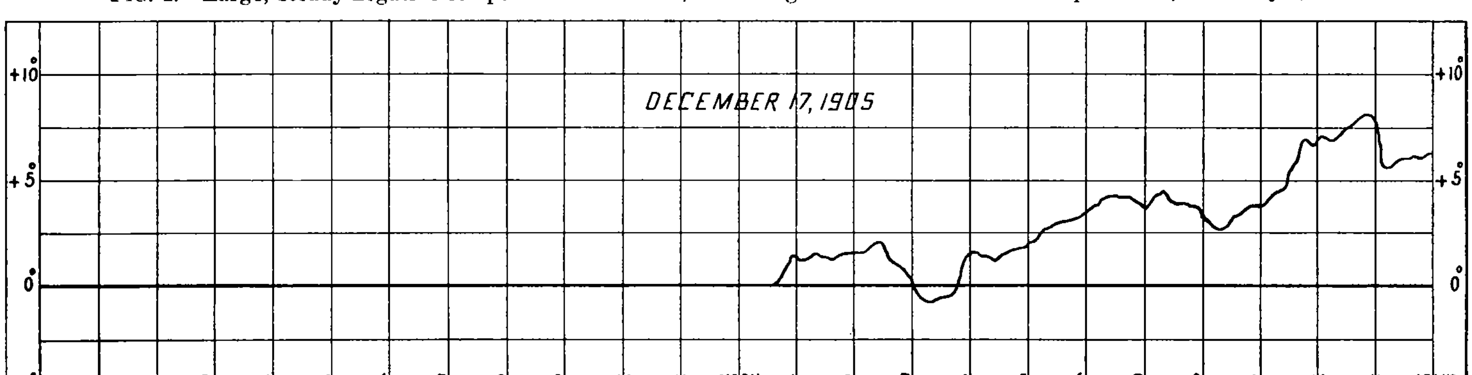

FIG. 3.—Increasing positive temperature difference, showing warm wave passing over high-level station, December 17, 1905.

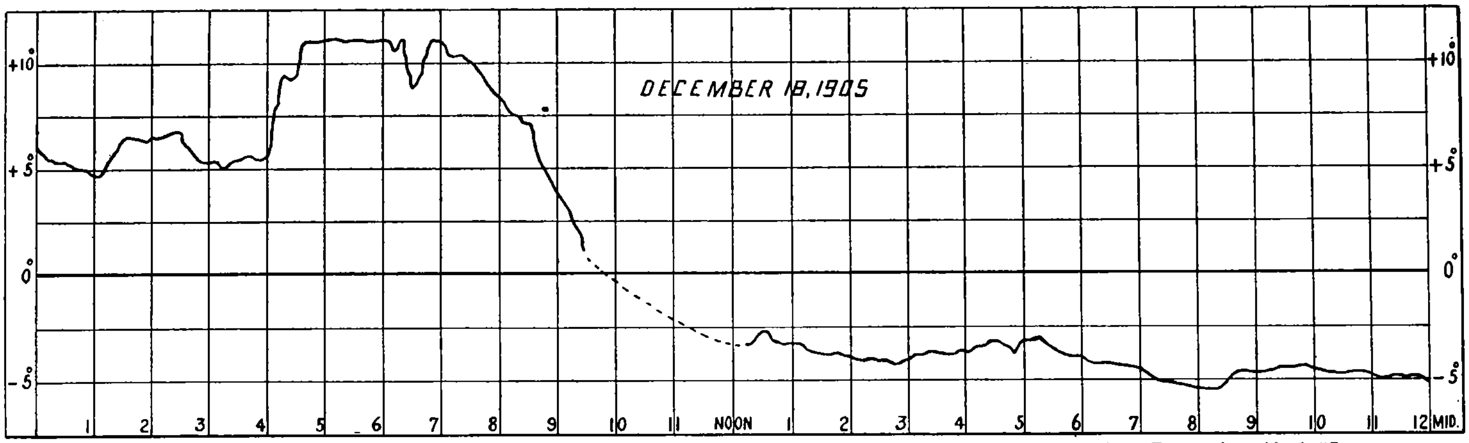

FIG. 4.—Decreasing positive temperature difference; warm wave coming down to low-level station, December 18, 1905.

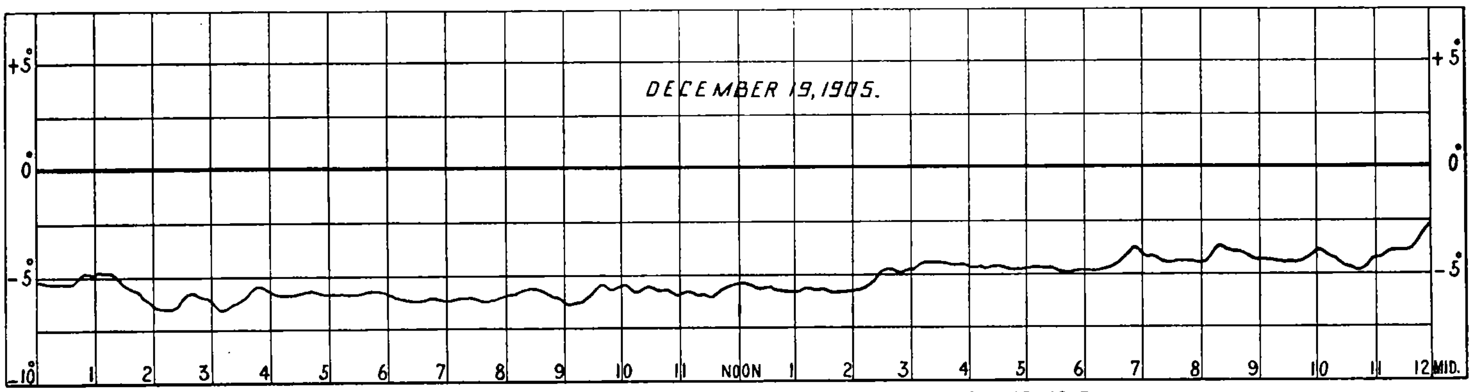

FIG. 5.—Normal negative temperature difference, December 19, 1905.

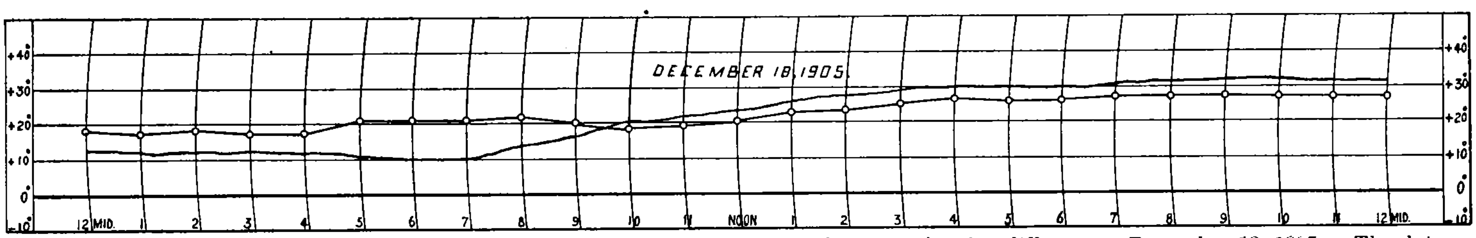

FIG. 6.—Thermogram at low level, with high-level temperatures plotted from the trace showing differences, December 18, 1905. (The dots on the hour lines indicate the high-level temperatures.)

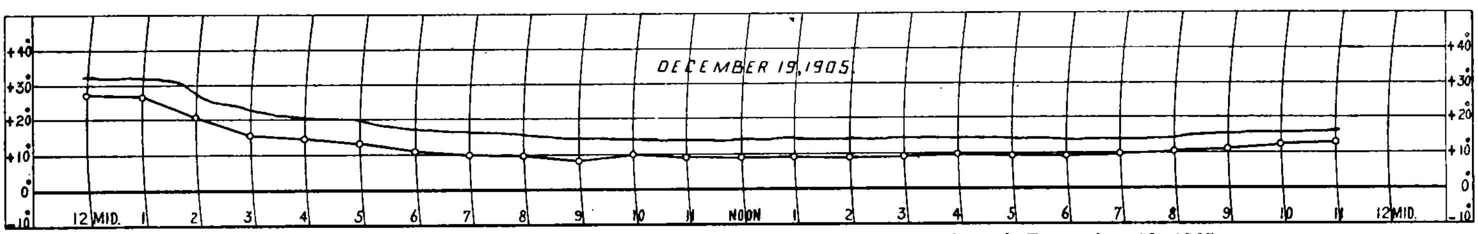

FIG. 7.—Thermogram at low level, with high-level temperatures plotted, December 19, 1905.

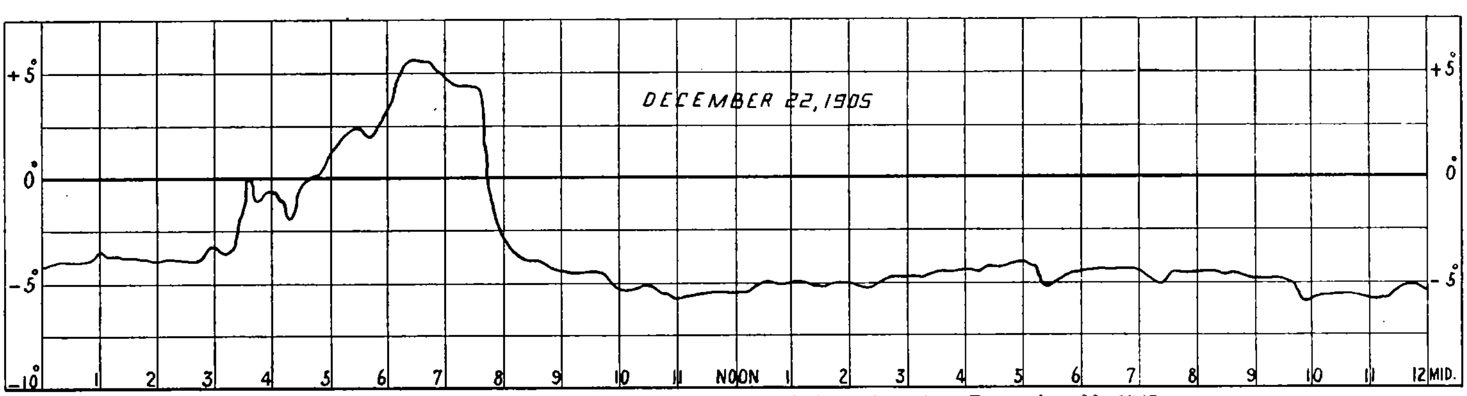

FIG. 8.—Temperature difference; warm wave of short duration, December 22, 1905.

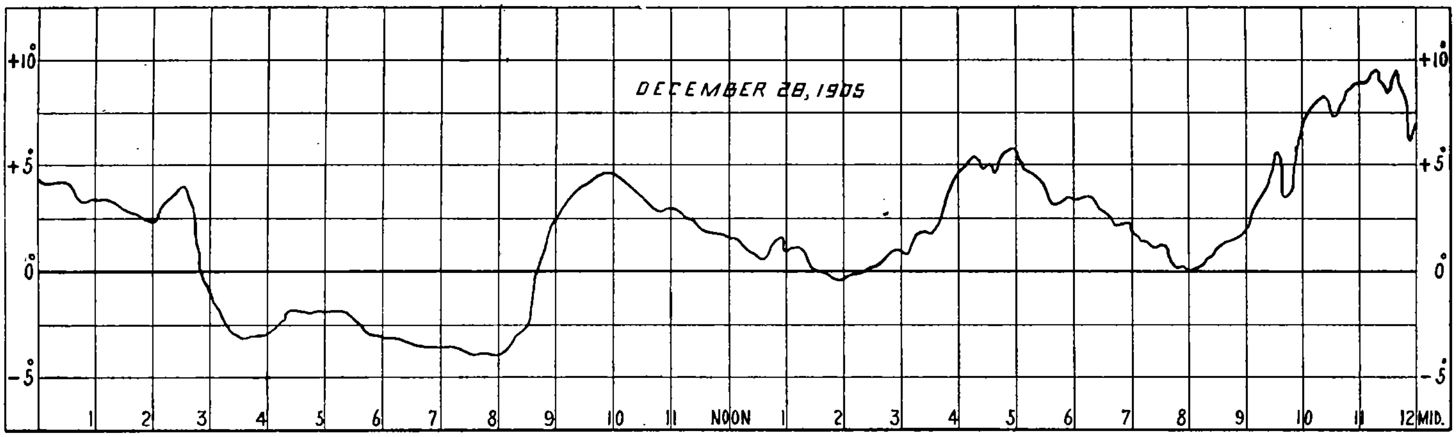

FIG. 9.—Temperature difference; succession of warm waves, December 28, 1905.

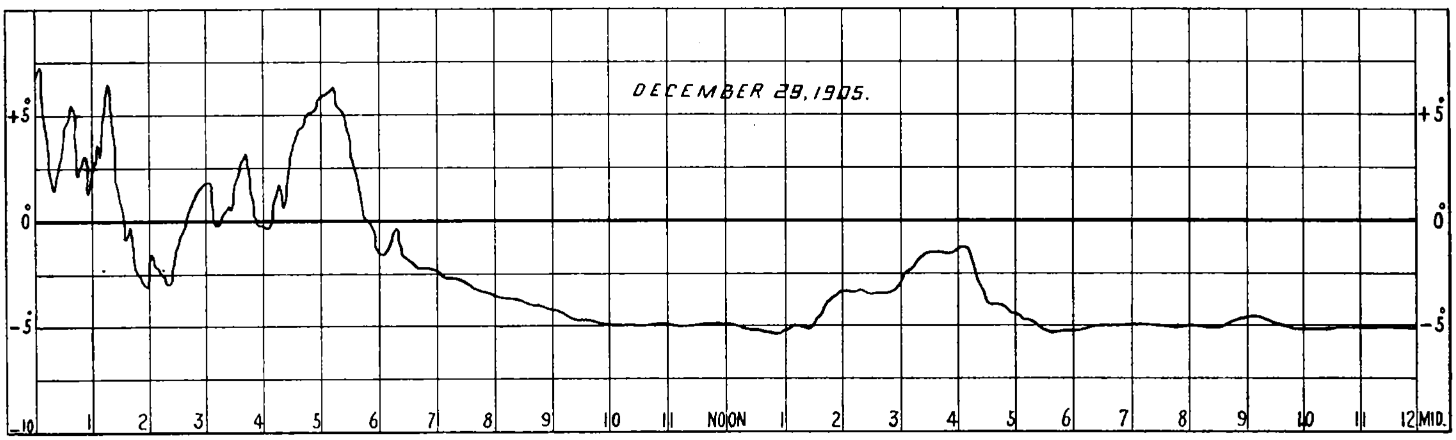

FIG. 10.—Temperature difference; short period waves imprest on the longer waves by a change of wind direction, December 29, 1905.

this month very large negative differences were recorded, and the severity of the weather may be gathered when it is observed that the average temperature at the observatory for the month is recorded as being over 8° below the mean for the previous thirty years. The average difference between the summit and observatory for that month was 11°, which is the largest average monthly difference so far obtained.

The remaining figures give the recorded differences and the temperatures at the observatory for part of December, 1905, in illustration of our method of temperature forecasting.

At noon on December 17 (fig. 3) the temperature on the mountain became warmer than at the lower station, and so continued for ten hours. The temperature at the lower point during this time fell slightly until after 7 a. m. on the 18th (fig. 6), when the change to warmer weather began, and extended thru more than 20°.

Before 10 a. m. on the 18th (fig. 4), while the temperature at the lower station was still increasing (fig. 6) the differential record rapidly returned to zero, and then showed a negative difference which continued to increase, at first rapidly and then slowly, for about sixteen hours. The change to lower temperature at the observatory took place at about 1:30 a. m. on the 19th (fig. 7) and continued thru 15°. The interval here noted between the change to a minus difference and the commencement of cold weather at the lower station amounted to sixteen hours. A difference of upwards of 5° was maintained between the stations for about twelve hours (fig. 5), indicating steady cold at the lower station, after which the difference decreased slightly until midnight of the 19th. Shortly afterward the approach of a warm wave was noted by a return to zero, and the lower station showed the expected change some ten hours later (10 a. m. of the 20th). In this case the recorded difference only just reached zero, and after four hours fell away from it. As was to be expected, the temperature change at the lower station was of correspondingly small dimensions.

After this the record remained at or slightly below the normal difference for the month, and no considerable change occurred in the air temperature until the 22d at 8 a. m. (fig. 8), when the approaching change was heralded by the differential thermometer at 3 a. m., or only five hours in advance. Again the plus indications were of slight duration and the warm period similarly brief. The following two days gave a period of steady temperature with a gradual approach to colder weather on the evening of the 24th, and no considerable fluctuation in difference from —5° until midnight on the 24th, when for a few hours the record showed a plus value, reaching +3°, and the air temperature rose to 30° at noon the following day, the 25th. Similar cases of advanced warning may be observed in the following days: A very extensive deviation to the plus side continued from 3 p. m. on the 27th to 6 a. m. on the 29th (figs. 9 and 10), and was followed by the long period of warm weather covering the greater part of the 28th, and the 29th, 30th, and 31st, and altho a normal minus deviation was recorded as early as 10 a. m. on the 29th (fig. 10), colder weather did not set in until midnight of the 30th. These results, presented in tabulated form to show the interval of warning of an approaching change in temperature, are as follows:

Time at which change was noted on differential record.		Character of indication.	Time at which expected change occurred at lower station.		Interval of warning.
1905.	Hour.		1905.	Hour.	
December 17	12 noon	Warmer	December 18	7 a. m.	19 hours.
December 18	10 a. m.	Colder	December 19	1:30 a. m.	16 hours.
December 19	12 midnight.	Warmer	December 20	10 a. m.	10 hours.
December 22	3 a. m.	Warmer	December 22	8 a. m.	5 hours.
December 24	12 midnight.	Warmer	December 25	12 noon	12 hours.

Figs. 6 and 7 show the temperatures obtained from figs. 4 and 5 plotted on the thermograph records which are obtained daily at the observatory. This shows at a glance the character of the deviations. The mountain temperatures can be obtained from the plot which is marked by the dots at the hour intervals. Fig. 9 is interesting as showing a series of warm waves of about 5-hour period, which is followed by fig. 10, showing waves of about 1-hour period, the temperature finally settling down to a steady negative difference the following day.

Elsewhere we have published a larger number of traces,[1] but the examples we give here illustrate what we are obtaining from our mountain records. It is very much to be desired that similar traces should be obtained at other stations for comparison. The question of how far the results we have obtained are due to any peculiarity of our location has yet to be settled.

Mount Royal is one of the Monteregian hills, of which there are several, all of volcanic origin, which rise above a very flat country. The nearest of these hills is Mount St. Bruno, 14 miles to the east, with an elevation of 560 feet. Beloeil Mountain comes next, about 24 miles from Montreal, but is considerably higher, about 1400 feet.

We desire some time to erect a thermometer on the summit of one of the higher mountains, such as Beloeil, but lack of funds renders this out of the question at the present moment.

The observations which have been made by Prof. J. E. Church, jr.,[2] on the summit of Mount Rose, to which our attention was directed by Professor Abbe during the past summer, seem to indicate similar advance changes. The observations are exceedingly difficult to obtain, and the heroic efforts of Professor Church to establish the Mount Rose Weather Observatory are vividly described in his interesting paper. The altitude of Mount Rose is 10,800 feet, vastly greater than the altitude of our high-level instrument, but the character of the mountain is that of a peak rising by itself, isolated from other land masses, similar to our more modest Mount Royal. Professor Church has compared the thermograph records obtained on the summit with similar records obtained at Reno, 6268 feet below, and finds advance times of warning for temperature changes at the lower level. Thus at noon on May 14 a period of low temperature set in on the mountain top thirty-six hours before the first appearance of frost in the adjacent valley. The time interval for a depression of temperature on Mount Rose to reach the region below at Reno is placed at from twenty-four to thirty-six hours. The time interval of warning which we have observed is shorter than that noted by Professor Church, but this is no doubt due to the very great difference in the altitudes of the respective stations. In one case it was observed that a gale of 40 miles per hour was met by the observer on the mountain top six hours in advance of its arrival at Reno. Here the high wind seems to have lessened the time of warning for the storm, just as we have found that a high wind with cold lessens the interval of the temperature fall at the lower station.

Should the time interval of warning be a question of altitude, as indicated by a comparison of Professor Church's results and our own, it would be of great interest as indicating the height at which meteorological changes have their origin. Simultaneous observations of temperature at different altitudes would thus be most instructive, when obtained on a recording apparatus such as ours placed at a low-level station. We believe that the complete success of this method of temperature forecasting depends on knowing at once the difference of temperature between the high and low levels. Thus several such arrangements would give at any moment the temperatures at various altitudes compared with a common level.

[1] Trans. Roy. Soc. Can., vol. 10, pp. 71–121 (1904), and vol. 12 (1906).

[2] Monthly Weather Review, June, 1906, Vol. XXXIV, p. 255.

COLLAPSE OF A HOLLOW LIGHTNING ROD.

In Nature, London, July 5, 1906, page 230, Prof. J. A. Pollock, of the University of Sydney, N. S. W., describes a lightning stroke passing down a hollow rod used as a lightning conductor, and crushing it inwards. As the copper was about one millimeter thick considerable force would be required to do this, but as the diameter of the rod is not given nothing more definite can be stated as to the necessary pressure.

It is well known that a lightning flash involves the sudden expansion of the air in the direct line of discharge, thus producing an explosive effect, which is doubtless the origin of the thunder.

The intensity of this effect may be greatly reinforced by the sudden conversion into vapor of any masses of water or other liquid that may lie in the path. In this way the bursting asunder of the limbs and bodies of trees and the boring of trenches in the ground is explained.

The collapse of the copper tubular conductor is attributed by Professor Pollock to compression produced by the electrodynamic action of the current when the tube was hot and plastic. An equally plausible explanation is offered by Dr. Irving Langmuir of New York, who has been investigating the dissociation of gases and vapors around highly heated wires, as set forth in the following letter of August 22.

In reply to your letter of August 18, I would say that it is not possible that the dissociation of water vapor on the surface of a hollow lightning rod could account for pressures sufficient to make the rod collapse. At the melting point of copper (1084° C.) the dissociation of water vapor under atmospheric pressure is only 0.005 per cent and even at the melting point of platinum (1710° C.) it is less than 1 per cent. Under higher pressure the dissociation is still less. Furthermore the dissociation, *even if complete*, would increase the pressure only 50 per cent—a small amount compared to the pressure due to the heating of the gases around the rod.

I would suggest as an explanation of the phenomenon the practically instantaneous (explosive) vaporization of a layer of water on the outside surface of the tubular rod. Even a thin film, if converted rapidly enough into steam, could produce very great pressure.

Even without the presence of a film of water the pressure might be produced by the explosive expansion of the air near the outer surface of the rod. It is probable that the air inside the tube would not be heated so rapidly or to such a high temperature as the air outside the tube, because the current thru the rod, being oscillatory, would practically be confined to the outer layers.

In a later letter, dated September 18, Doctor Langmuir remarks:

Professor Pollock's explanation is interesting. * * * I do not know whether he made any calculation to see whether the electromagnetic forces would be of the order of magnitude required to crush a copper tube. The problem interested me, so I endeavored to make such a calculation. According to Pockel, W. Kohlrausch, and L. Weber the current in a lightning discharge is, on the average, 10,000 amperes, with a maximum value of 20,000 amperes. Taking this last figure as the basis for the calculation, and assuming the outside diameter of the rod to be 1 centimeter and the inside diameter 0.8 centimeter, I find that the electromagnetic force on the outside of the tube would be equivalent to a pressure of 42 pounds per square inch. This would cause compressive stresses in the tube of 210 pounds per square inch. This is calculated on the assumption that the current flows uniformly thruout the cross section of the copper of the tube. If the current is limited to the outside layers, because of its oscillatory character, the pressure would be about 14 per cent less.

A similar calculation, worked out for the case that the outer diameter is 0.4 centimeter and the inner diameter 0.2 centimeter, gives for the pressure 330 pounds per square inch, and for the stress in the copper 670 pounds per square inch. With an oscillatory current the pressures would be about 35 per cent less than these.

It hardly seems probable that such small pressures lasting for such a very short time as that during which the discharge lasts could produce the collapse of the rod. Copper does not become very soft when heated below its melting point, so we would not expect it to yield to pressure of such small magnitude. * * *

Of course the data on which the above calculations are based are too uncertain, and the results come out too nearly of the order of magnitude necessary for the crushing of the rod, to enable one to prove conclusively that the electromagnetic force is not the cause of the collapse. The pressure is proportional to the square of the current, so that a current of 40,000 amperes would produce four times the effects calculated above.